

What is claimed is:

1. A radio sensor device comprising:
 - a. a first radio receiver capable of receiving radio signals in a radio frequency band;
 - b. a spectrum analysis system coupled to the first radio receiver that produces spectrum activity information representative of the activity in the frequency band;
 - c. a baseband signal processing section that demodulates baseband signals transmitted by other devices on a wireless network in the frequency band according to a communication protocol;
 - d. a second radio receiver coupled to the baseband signal processing section that receives signals transmitted on the wireless network and couples received signals to the baseband signal processing section; and
 - e. a processor coupled to the spectrum analysis system and to the baseband signal processing section, wherein the processor executes one or more programs to analyze packets transmitted on the wireless network in the frequency band based on signals demodulated by the baseband signal processing section and to classify radio signals occurring in the frequency band based on the spectrum activity information output by the spectrum analysis system.
2. The radio sensor device of claim 1, wherein the spectrum analysis system produces spectrum activity information including pulse events representing occurrences of radio frequency pulses that match one or more criteria including one or more of bandwidth, duration and center frequency.
3. The radio sensor device of claim 1, and further comprising a buffer that stores digital data derived from energy received by the first radio receiver for an interval of time.
4. The radio sensor device of claim 3, wherein the processor executes a program to trigger the buffer to capture the digital data associated with reception of a signal transmitted by a device to be located and a reference signal transmitted by another device, and from the digital data the

processor computes a time difference of arrival at the sensor device of the signal transmitted by the device to be located and the reference signal.

5. The radio sensor device of claim 1, wherein the processor generates statistics about packets transmitted in the frequency band between devices in the wireless network including type of packets, volume of packet traffic, number of packet retransmissions and identifiers of devices transmitting packets.
6. The radio sensor device of claim 5, wherein the processor generates statistics on a received packets on a per channel, per device or per packet field identifier basis.
7. The radio sensor device of claim 5, wherein the processor filters packets to be analyzed for purposes of generating statistics.
8. The radio sensor device of claim 1, wherein the processor generates a quantity that represents a general quality of the frequency band based on the number and the type of signals that are determined to be occurring in the frequency band.
9. The radio sensor device of claim 1, wherein the baseband signal processing section modulates signals in accordance with the communication protocol for transmission on the wireless network, and further comprising a transmitter coupled to the baseband signal processing section for transmitting signals modulated by the baseband signal processing section.
10. The radio sensor device of claim 9, wherein the processor controls the baseband signal processing section to modulate a reference signal in accordance with the communication protocol for transmission on the wireless network, wherein the reference signal is used in a process to locate a device operating in the frequency band.
11. The radio sensor device of claim 1, wherein the processor generates signals to control the first radio receiver and the second radio receiver independently of one another.
12. A system for monitoring activity in a shared frequency band, comprising:

- a. a plurality of radio sensors positioned at various locations in a region where activity in a shared radio frequency band is occurring, each of the plurality of radio sensors comprising:
 - i. a first radio receiver capable of receiving radio signals in a radio frequency band;
 - ii. a spectrum analysis system coupled to the first radio receiver that produces spectrum activity information representative of the activity in the frequency band;
 - iii. a baseband signal processing section that demodulates baseband signals transmitted by other devices on a wireless network in the frequency band according to a communication protocol;
 - iv. a second radio receiver coupled to the baseband signal processing section that receives signals transmitted on the wireless network and couples received signals to the baseband signal processing section; and
 - v. a processor coupled to the spectrum analysis system and to the baseband signal processing section, wherein the processor executes one or more programs to analyze packets transmitted on the wireless network in the frequency band based on signals demodulated by the baseband signal processing section and to classify radio signals occurring in the frequency band based on the spectrum activity information output by the spectrum analysis system; and
 - b. a server coupled to the plurality of radio sensors that receives data from each of the plurality of radio sensors and that executes functions to process the data supplied by the plurality of sensors.
13. The system of claim 12, wherein the server communicates with each of the plurality of radio sensors to configure parameters associated with generation of packet statistics and classification of signals by each radio sensor.

14. The system of claim 12, wherein the server configures the types of signals to be classified by one or more radio sensors.
15. The system of claim 12, wherein the baseband signal processing section modulates signals in accordance with the communication protocol for transmission on the wireless network, and further comprising a transmitter coupled to the baseband signal processing section for transmitting signals modulated by the baseband signal processing section.
16. The system of claim 15, wherein the processor controls the baseband signal processing section to modulate a reference signal in accordance with the communication protocol for transmission on the wireless network, wherein the reference signal is used in a process to locate a device operating in the frequency band.
17. The system of claim 12, wherein each of the radio sensors comprises a buffer that stores digital data derived from energy received by the first radio receiver for an interval of time.
18. The system of claim 17, wherein the server sends a location set-up message to a select group of radio sensors to prepare them for a location operation, wherein the message identifies the radio sensor that is to act as a master reference terminal and identifies the device to be located.
19. The system of claim 18, wherein in response to receiving the location set-up message from the server, the processor in each radio sensor in the select group executes a program to trigger the buffer to begin continuously capturing digital data associated with energy received by the radio receiver.
20. The system of claim 19, wherein in the master reference terminal sensor, the baseband signal processing section modulates signals in accordance with the communication protocol for transmission on the wireless network, and further comprising a transmitter coupled to the baseband signal processing section for transmitting signals modulated by the baseband signal processing section.

21. The system of claim 20, wherein the master reference terminal sensor transmits a first signal addressed to the device to be located, and in response thereto, the device to be located transmits a first response signal.
22. The system of claim 21, wherein in response to receiving the first response signal, the master reference terminal sensor transmits a second signal to the device to be located and the device to be located transmits a second response signal.
23. The system of claim 22, wherein the radio sensors in the select group and the master reference terminal sensor process the data captured by their buffers to determine the time of arrival of each of the signals and to compute the time difference of arrival between the first signal and the first response signal and between the second signal and the second response signal, and transmit the time difference of arrival data to the server.
24. The system of claim 22, wherein the device to be located is a device compatible with the IEEE 802.11 standards, and wherein master reference terminal sensor transmits the first signal as a request-to-send (RTS) frame and the first response signal is a clear-to-send (CTS) frame, and the master reference terminal sensor transmits the second signal as a Probe Request frame to the device to be located and the second response signal is an ACK frame.
25. The system of claim 21, wherein the radio sensors in the select group and the master reference terminal sensor process the data captured by their buffers to determine the time of arrival of each of the signals and to compute the time difference of arrival between the first signal and the first response signal, and transmit the time difference of arrival data to the server.
26. The system of claim 21, wherein the server computes the location of the device to be located based on the time difference of arrival data received from the select group of radio sensors.
27. The system of claim 21, wherein the device to be located is a device compatible with the IEEE 802.11 standards, and wherein master reference

terminal sensor transmits the first signal as a request-to-send (RTS) frame and the first response signal is a clear-to-send (CTS) frame.

28. The system of claim 12, wherein the server aggregates the data from the plurality of radio sensors and formats portions of the data for interface to a network management application.
29. The system of claim 12, wherein the server stores data from the plurality of radio sensors in a database.
30. The system of claim 29, wherein the server stores in the database configuration information associated with functions of the server and the radio sensors and data generated by the plurality of radio sensors.
31. The system of claim 29, wherein the server stores data from the radio sensors in a plurality of interrelated data structures.
32. The system of claim 31, wherein the server stores data pertaining to the signals determined to be occurring in the frequency band by one or more radio sensors in a classification statistics data structure containing data about the signal in fields including a device-ON indicator, a classification identifier that identifies a device type, a product identifier that identifies a specific product and a confidence measure that indicates a certainty of the classification identifier.
33. The system of claim 31, wherein the server stores data pertaining to signals that are interferers to the wireless network determined to be occurring in the frequency band in an interferer data structure in fields that include a device-ON indicator, a classification identifier that identifies a device type, a product identifier that identifies a specific product and a confidence measure that indicates a certainty of the classification identifier.
34. The system of claim 29, wherein the server stores data associated with events occurring in the frequency band and/or wireless network in an event data structure and an event types data structure that is linked to the event data structure.

35. The system of claim 34, wherein the server stores data in the event types data structure in fields including one or more of name, severity level, summary and description.
36. The system of claim 12, wherein the server executes a performance function that monitors and generates events related to the performance of the wireless network, a discovery function that monitors and generates events pertaining to devices operating in the wireless network or other radio frequency emitters in the frequency band and a security function that monitors and generates events related to security threats to the wireless network.
37. The system of claim 36, wherein the server further executes a location function that communicates with a select group of radio sensors to obtain data from the select group of radio sensors that the location function uses to determine locations of wireless network and other radio frequency emitters in the frequency band; a protocol manager function that aggregates packet statistics generated by the radio sensors; and a radio frequency manager function that aggregates spectrum activity information and signal classification information generated by the radio sensors.
38. The system of claim 37, wherein the server executes the discovery function to interact with the location function in order to obtain a location of a wireless network device other radio frequency emitters determined by the discovering manager to be discovered by a radio sensor.
39. The system of claim 37, wherein the server executes the security function to interact with the location function in order to obtain a location of a wireless network device or other radio frequency emitters that pose a security threat to the wireless network.
40. The system of claim 37, wherein the server executes the performance function to interact with the protocol manager function to monitor packet activity in the wireless network for security threats.
41. The system of claim 36, wherein the performance function, discovery function and security function are configurable with respect to the types of

activity they monitor in the data supplied by the location function, protocol manager function and radio frequency manager function.

42. The system of claim 12, wherein the processor in at least one radio sensor generates a measurement of the general quality of the frequency band in its proximity based on the number and type of signals determined to be occurring in the frequency band.
43. The system of claim 12, wherein the server manages information pertaining to a building site in which a plurality of radio sensors are located, and a plurality of zones within the building site in which one or more radio sensors are located.
44. The system of claim 43, wherein based on data collected from the plurality of radio sensors, the server generates for each zone, an indication of one or more of a degree of severity of interfering signal activity, wireless network performance level, and security status of the wireless network.
45. The system of claim 44, and further comprising a plurality of servers each coupled to an associated plurality of radio sensors, and a super server coupled to the plurality of servers to manage the plurality of servers.
46. The system of claim 12, wherein the server generates a list of devices discovered in the frequency band based on the signals determined to be occurring in the frequency band by the plurality of radio sensors.
47. The system of claim 46, wherein the server generates, for each device discovered in the frequency band, information selected from the group consisting of: an identifier of the type of device (interferer or wireless network), time that the device is discovered, time the device is determined to no longer be present, identifier of the one or more radio sensor(s) that discovered the device, physical location of the device and the time at which the location was determined and indication of movement of a device that was designated as a fixed location device.
48. The system of claim 46, wherein the server generates, for each device that is discovered and determined to be an interferer to the wireless network, information selected from the group consisting of: general classification

of the device, specific product type if it has been determined, measure of confidence that the classification and/or specific product type are accurate, alternate classification and specific product types and associated measure of confidences, type of device including frequency hopping, non-frequency hopping and continuous signal.

49. The system of claim 12, wherein the server configures thresholds for statistics derived from the data supplied by the radio sensors, which when crossed, the server generates an alarm event.
50. The system of claim 49, wherein the server configures a threshold for one or more of the following statistics derived from data generated by the radio sensors: number of interfering signals occurring in a channel, percentage of time that the power level for a channel remains above a power threshold, number of radio frequency pulses occurring in a channel during a measurement interval, a measurement of the general quality of a channel based on the number and type of interfering signals to the wireless network determined to be occurring in the frequency band.
51. The system of claim 12, wherein the server generates events associated with activity detected in the wireless network and/or frequency band.
52. The system of claim 51, wherein the server generates information indicating an event type, wherein the event type is selected from the group consisting of: discovery of a new device, performance of the wireless network, security of the wireless network and location of a device.
53. The system of claim 52, wherein for an event related to a security issue, the server generates an indication of the type of security issue selected from the group consisting of: a device accessing the wireless network from an unauthorized location, the type of device accessing the wireless network from an unauthorized location, an unauthorized access point operating on the wireless network, a protocol level denial of attack on the wireless network and a radio signal level denial of attack on the wireless network characterized by a radio signal of a relatively long duration across a substantial portion of the frequency band.

54. The system of claim 53, wherein the server generates for each event information selected from the group consisting of: an identifier of the type of event, a timestamp associated with the time that the event occurred, a list of the radio sensors that detected the event, an identifier for the site in which the event occurred, an identifier for a zone in the site in which the event occurred and an indication of the severity of the event.
55. The system of claim 12, wherein the server is configurable by a network management application through an application programming interface (API) with respect to the type of information requested about activity in the wireless network and/or frequency band, and the server supplies data from the plurality of radio sensors to the network management application through the API.
56. A method for interfacing a network management application with a plurality of radio sensor devices that monitor activity in a frequency band in which a wireless network and other interfering signal activity may be occurring, comprising steps of:
 - a. receiving configurations from the network management application concerning the type of information requested about activity in the wireless network and/or frequency band; and
 - b. supplying data concerning activity in the wireless network and/or frequency band according to configurations.
57. The method of claim 56, wherein the step of receiving configurations comprises receiving configuration parameters concerning types of interfering signals to be detected in the frequency band and parameters about traffic activity in the wireless network.
58. The method of claim 56, wherein the step of supplying data comprises supplying a generalized description of the quality of the frequency band based on the number and type of interfering signals determined to be occurring in the frequency band or in a particular channel of the frequency band.

59. The method of claim 56, wherein the step of supplying data comprises supplying a list of devices discovered in the frequency band.
60. The method of claim 59, wherein the step of supplying data comprises supplying, for each device discovered in the frequency band, information selected from the group consisting of: an identifier of the type of device (interferer or wireless network), time that the device is discovered, time the device is determined to no longer be present, identifier of the sensor or sensors that discovered the device, physical location of the device and the time at which the location was determined and indication of movement of a device that was designated as a fixed location device.
61. The method of claim 60, wherein the step of supplying data comprises supplying, for each device that is discovered and determined to be an interferer to the wireless network, information selected from the group consisting of: general classification of the device, specific product type if it can be determined, measure of confidence that the classification and/or specific product type are accurate, alternate classification and specific product types and associated measure of confidences, type of device including frequency hopping, non-frequency hopping and continuous signal.
62. The method of claim 56, wherein the step of receiving configurations comprises receiving information describing thresholds for statistics derived the data supplied by the radio sensor devices, which when crossed, causes generation of an alarm event.
63. The method of claim 62, wherein the step of receiving configurations comprises receiving a threshold for one or more of the following statistics derived from data generated by the radio sensor devices: number of interfering signals occurring in a channel, percentage of time that the power level for a channel remains above a power threshold, number of radio frequency pulses occurring in a channel during a measurement interval, a measurement of the general quality of a channel based on the

number and type of interfering signals to the wireless network determined to be occurring in the frequency band.

64. The method of claim 56, wherein the step of supplying data comprises supplying event alerts associated with activity detected in the wireless network and/or frequency band.
65. The method of claim 64, wherein the step of supplying data comprising supplying information indicating the type of event alert, wherein the event type is selected from the group consisting of: discovery of a new device, performance of the wireless network, security of the wireless network and location of a device.
66. The method of claim 65, wherein the step of supplying data comprises supplying for an event related to a security issue an indication of the type selected from the group consisting of: a device accessing the wireless network from an unauthorized location, the type of device accessing the wireless network from an unauthorized location, an unauthorized access point operating on the wireless network, a protocol level denial of attack on the wireless network and a radio signal level denial of attack on the wireless network characterized by a radio signal of a relatively long duration across a substantial portion of the frequency band.
67. The method of claim 66, wherein the step of supplying data comprises generating for each event information selected from the group consisting of: an identifier of the type of event, a timestamp associated with the time that the event occurred, a list of the radio sensor devices that detected the event, an identifier for the site in which the event occurred, an identifier for a zone in the site in which the event occurred and an indication of the severity of the event.
68. A method for interfacing a network management application with a plurality of radio sensor devices that monitor activity in a frequency band in which a wireless network and other interfering signal activity may be occurring, comprising steps of:

- a. generating configurations at the network management application concerning the type of information requested about activity in the wireless network and/or frequency band; and
 - b. receiving data concerning activity in the wireless network and/or frequency band according to configurations.
69. The method of claim 68, wherein the step of generating configurations comprises generating configuration parameters concerning types of interfering signals to be detected in the frequency band and parameters concerning statistics pertaining to traffic in the wireless network.
70. The method of claim 69, wherein the step of receiving data comprises receiving a generalized description of the quality of the frequency band based on the number and type of interfering signals determined to be occurring in the frequency band or in a particular channel of the frequency band.
71. The method of claim 69, wherein the step of receiving data comprises receiving a list of devices discovered in the frequency band.
72. The method of claim 71, wherein the step of receiving data comprises receiving, for each device discovered in the frequency band, information selected from the group consisting of: an identifier of the type of device (interferer or wireless network), time that the device is discovered, time the device is determined to no longer be present, identifier of the one radio sensor devices that discovered the device, physical location of the device and the time at which the location was determined and indication of movement of a device that was designated as a fixed location device.
73. The method of claim 72, wherein the step of receiving data comprises receiving, for each device that is discovered and determined to be an interferer to the wireless network, information selected from the group consisting of: general classification of the device, specific product type if it can be determined, measure of confidence that the classification and/or specific product type are accurate, alternate classification and specific product types and associated measure of confidences, type of device

including frequency hopping, non-frequency hopping and continuous signal.

74. The method of claim 69, wherein the step of generating configurations comprises generating information describing thresholds for statistics derived the data supplied by the radio sensor devices, which when crossed, causes generation of an alarm event.
75. The method of claim 74, wherein the step of generating configurations comprises designating a threshold for one or more of the following statistics derived from data generated by the radio sensor devices: number of interfering signals occurring in a channel, percentage of time that the power level for a channel remains above a power threshold, number of radio frequency pulses occurring in a channel during a measurement interval, a measurement of the general quality of a channel based on the number and type of interfering signals to the wireless network determined to be occurring in the frequency band.
76. A processor readable medium encoded with instructions that, when executed by a processor, cause the processor to perform steps of: generating configurations concerning the type of information requested about activity in a wireless network and in a frequency band in which the wireless network operates; and receiving data containing information concerning activity in the wireless network and frequency band according to the configurations.
77. A method for analyzing data pertaining to activity in a shared radio frequency band comprising steps of:
 - a. receiving data from each of a plurality of radio sensor devices deployed in different locations to detect activity in the radio frequency band, wherein the data includes identifiers types of signals determined to be occurring in the frequency band and statistics concerning traffic on wireless network operating in the radio frequency band;
 - b. aggregating the data; and

c. analyzing the data.

78. The method of claim 77, wherein the step of analyzing comprises executing a performance function that monitors performance of the wireless network based on aggregated traffic statistics, executing a discovery function that monitors and generates events pertaining to devices operating in the wireless network or other radio frequency emitters in the frequency band, and executing a security function that monitors and generates events related to security threats to the wireless network.